CHAPTER

2 Properties of Matter

the BIG idea

Matter has properties that can be changed by physical and chemical processes.

Key Concepts

SECTION 2.1
Matter has observable properties.
Learn how to recognize physical and chemical properties.

SECTION 2.2
Changes of state are physical changes.
Learn how energy is related to changes of state.

SECTION 2.3
Properties are used to identify substances.
Learn how the properties of substances can be used to identify them and to separate mixtures.

Internet Preview

CLASSZONE.COM

Chapter 2 online resources: Content Review, Simulation, three Resource Centers, Math Tutorial, Test Practice

What properties could help you identify this sculpture as sugar?

EXPLORE the BIG idea

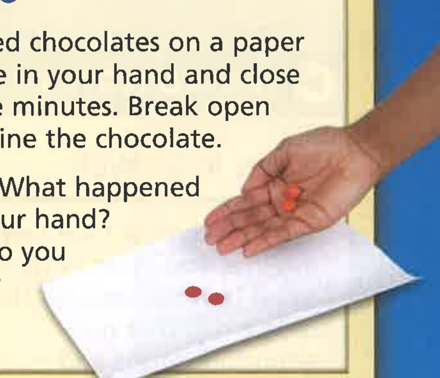
Float or Sink

Form a piece of clay into a solid ball or cube. Place it in a bowl of water. Notice if it floats or sinks. Then mold the clay into a boatlike shape. Notice if this new object floats or sinks.

Observe and Think What did you change about the clay? What didn't you change? What would happen if you filled the boat with water?

Hot Chocolate

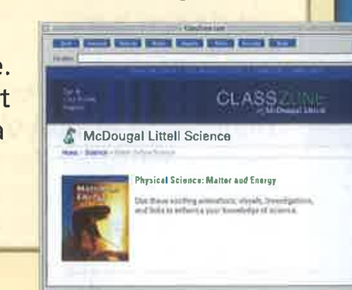
Place two candy-coated chocolates on a paper towel. Place two more in your hand and close your hand. Wait three minutes. Break open the candies and examine the chocolate.



Observe and Think What happened to the chocolate in your hand? on the towel? What do you think accounts for any differences you see?

Internet Activity: Physical and Chemical Changes

Go to **ClassZone.com** to see how materials can go through physical and chemical changes.



Observe and Think Think about each change. What can you infer about the difference between a physical change and a chemical change?

NSTA SCiLINKS scilinks.org

Physical Properties of Matter **Code: MDL062**

CHAPTER 2
Getting Ready to Learn

CONCEPT REVIEW

- Everything is made of matter.
- Matter has mass and volume.
- Atoms combine to form molecules.

VOCABULARY REVIEW

mass p. 10
volume p. 11
molecule p. 18
states of matter p. 27

CONTENT REVIEW
CLASSZONE.COM
Review concepts and vocabulary.

TAKING NOTES

MAIN IDEA WEB

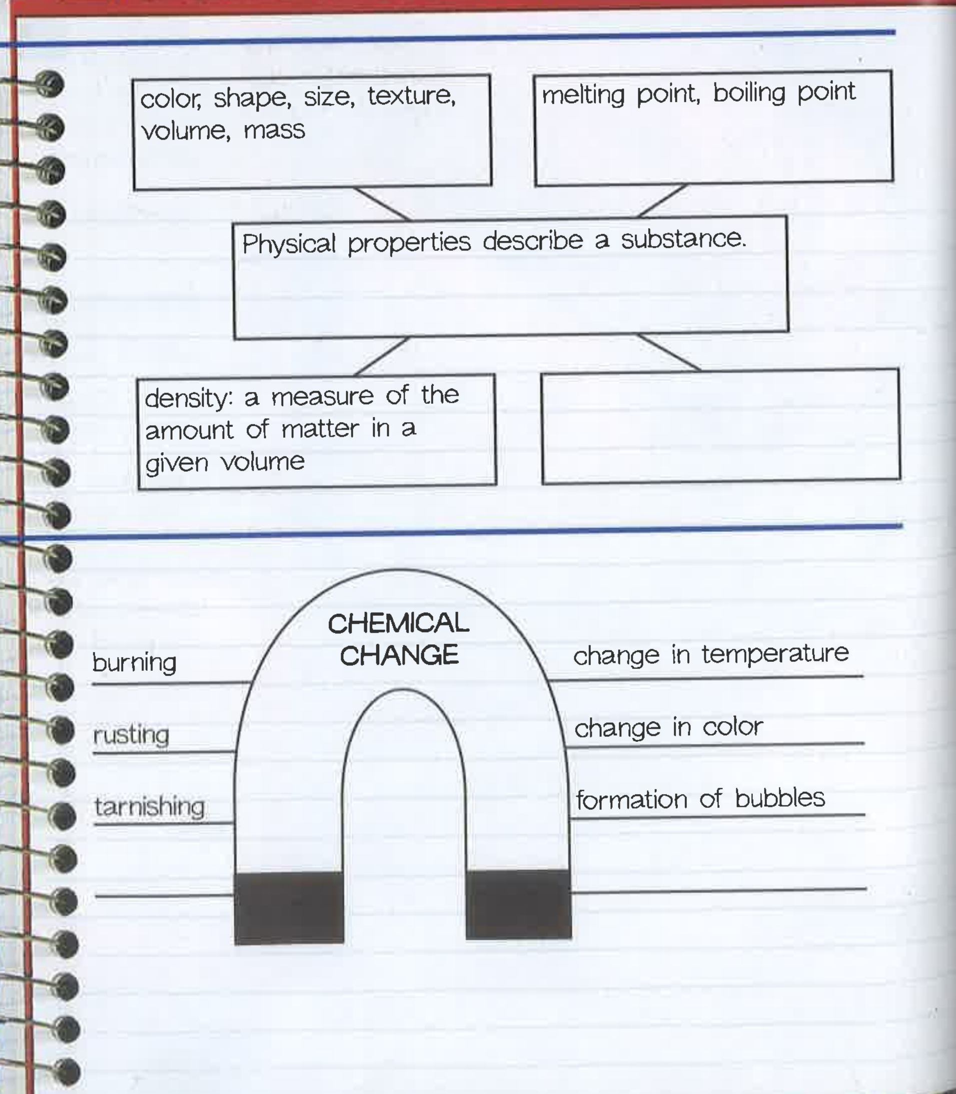
Write each new blue heading in a box. Then write notes in boxes around the center box that give important terms and details about that heading.

VOCABULARY STRATEGY

Think about a vocabulary term as a **magnet word** diagram. Write related terms and ideas in boxes around it.

See the Note-Taking Handbook on pages R45–R51.

SCIENCE NOTEBOOK



KEY CONCEPT
2.1 Matter has observable properties.

BEFORE, you learned
- Matter has mass and volume
- Matter is made of atoms
- Matter exists in different states

NOW, you will learn
- About physical and chemical properties
- About physical changes
- About chemical changes

VOCABULARY

physical property p. 41
density p. 43
physical change p. 44
chemical property p. 46
chemical change p. 46

EXPLORE Physical Properties

How can a substance be changed?

PROCEDURE

1. Observe the clay. Note its physical characteristics, such as color, shape, texture, and size.
2. Change the shape of the clay. Note which characteristics changed and which ones stayed the same.

MATERIAL
rectangular piece of clay

WHAT DO YOU THINK?
- How did reshaping the clay change its physical characteristics?
- How were the mass and the volume of the clay affected?

Physical properties describe a substance.

What words would you use to describe a table? a chair? the sandwich you ate for lunch? You would probably say something about the shape, color, and size of each item. Next you might consider whether it is hard or soft, smooth or rough to the touch. Normally, when describing an object, you identify the characteristics of the object that you can observe without changing the identity of the object.

The characteristics of a substance that can be observed without changing the identity of the substance are called **physical properties.** In science, observation can include measuring and handling a substance. All of your senses can be used to detect physical properties. Color, shape, size, texture, volume, and mass are a few of the physical properties you probably have encountered.

VOCABULARY
Make a magnet word diagram in your notebook for *physical property.*

CHECK YOUR READING Describe some of the physical properties of your desk.

Physical Properties

How do you know which characteristics are physical properties? Just ask yourself whether observing the property involves changing the substance to a different substance. For example, you can stretch a rubber band. Does stretching the rubber band change what it is made of? No. The rubber band is still a rubber band before and after it is stretched. It may look a little different, but it is still a rubber band.

Mass and volume are two physical properties. Measuring these properties does not change the identity of a substance. For example, a lump of clay might have a mass of 200 grams (g) and a volume of 100 cubic centimeters (cm^3). If you were to break the clay in half, you would have two 100 g pieces of clay, each with a volume of 50 cm^3. You can bend and shape the clay too. Even if you were to mold a realistic model of a car out of the clay, it still would be a piece of clay. Although you have changed some of the properties of the object, such as its shape and volume, you have not changed the fact that the substance you are observing is clay.

REMINDER
Because all formulas for volume involve the multiplication of three measurements, volume has a unit that is cubed (such as cm^3).

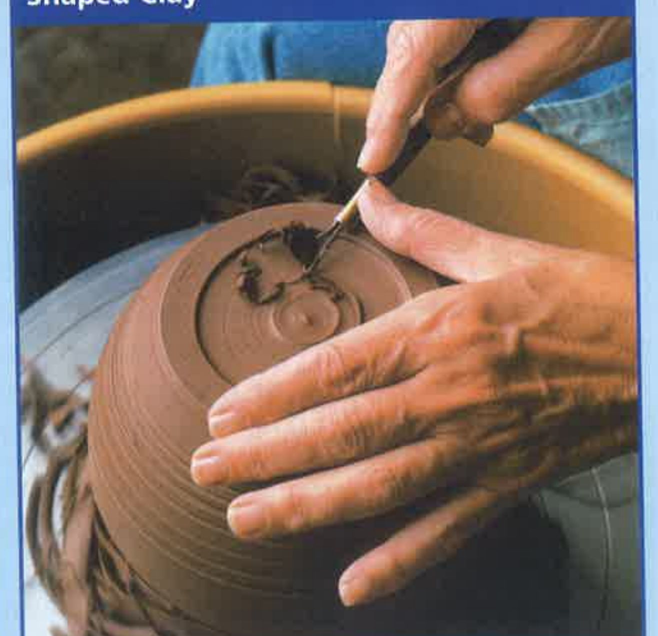
CHECK YOUR READING Which physical properties listed above are found by taking measurements? Which are not?

Physical Properties

Physical properties of clay—such as volume, mass, color, texture, and shape—can be observed without changing the fact that the substance is clay.

Block of Clay

Shaped Clay



READING VISUALS COMPARE AND CONTRAST Which physical properties do the two pieces of clay have in common? Which are different?

Density

The relationship between the mass and the volume of a substance is another important physical property. For any substance, the amount of mass in a unit of volume is constant. For different substances, the amount of mass in a unit of volume may differ. This relationship explains why you can easily lift a shoebox full of feathers but not one filled with pennies, even though both are the same size. A volume of pennies contains more mass than an equal volume of feathers. The relationship between mass and volume is called density.

Density is a measure of the amount of matter present in a given volume of a substance. Density is normally expressed in units of grams per cubic centimeter (g/cm^3). In other words, density is the mass in grams divided by the volume in cubic centimeters.

$$\text{Density} = \frac{\text{mass}}{\text{Volume}} \qquad D = \frac{m}{V}$$

How would you find the density of 200 g of clay with a volume of 100 cm^3? You calculate that the clay has a density of 200 g divided by 100 cm^3, or 2 g/cm^3. If you divide the clay in half and find the density of one piece of clay, it will be 100 g/50 cm^3, or 2 g/cm^3—the same as the original piece. Notice that density is a property of a substance that remains the same no matter how much of the substance you have.

READING TIP
The density of solids is usually measured in grams per cubic centimeter (g/cm^3). The density of liquids is usually measured in grams per milliliter (g/mL). Recall that 1 mL = 1 cm^3.

Calculating Density

Sample Problem

A glass marble has a volume of 5 cm^3 and a mass of 13 g. What is the density of glass?

What do you know? Volume = 5 cm^3, mass = 13 g

What do you want to find out? Density

Write the formula: $D = \frac{m}{V}$

Substitute into the formula: $D = \frac{13\ g}{5\ cm^3}$

Calculate and simplify: $D = 2.6\ g/cm^3$

Check that your units agree: Unit is g/cm^3. Unit of density is g/cm^3. Units agree.

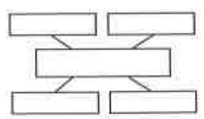
Answer: $D = 2.6\ g/cm^3$

Practice the Math

1. A lead sinker has a mass of 227 g and a volume of 20 cm^3. What is the density of lead?
2. A glass of milk has a volume of 100 mL. If the milk has a mass of 103 g, what is the density of milk?

Physical Changes

MAIN IDEA WEB
As you read, organize your notes in a web.



You have read that a physical property is any property that can be observed without changing the identity of the substance. What then would be a physical change? A **physical change** is a change in any physical property of a substance, not in the substance itself. Breaking a piece of clay in half is a physical change because it changes only the size and shape of the clay. Stretching a rubber band is a physical change because the size of the rubber band changes. The color of the rubber band sometimes can change as well when it is stretched. However, the material that the rubber band is made of does not change. The rubber band is still rubber.

What happens when water changes from a liquid into water vapor or ice? Is this a physical change? Remember to ask yourself what has changed about the material. Ice is a solid and water is a liquid, but both are the same substance—both are composed of H_2O molecules. As you will read in more detail in the next section, a change in a substance's state of matter is a physical change.

CHECK YOUR READING How is a physical change related to a substance's physical properties?

A substance can go through many different physical changes and still remain the same substance. Consider, for example, the changes that happen to the wool that ultimately becomes a sweater.

1. Wool is sheared from the sheep. The wool is then cleaned and placed into a machine that separates the wool fibers from one another. Shearing and separating the fibers are physical changes that change the shape, volume, and texture of the wool.
2. The wool fibers are spun into yarn. Again, the shape and volume of the wool change. The fibers are twisted so that they are packed more closely together and are intertwined with one another.
3. The yarn is dyed. The dye changes the color of the wool, but it does not change the wool into another substance. This type of color change is a physical change.
4. Knitting the yarn into a sweater also does not change the wool into another substance. A wool sweater is still wool, even though it no longer resembles the wool on a sheep.

It can be difficult to determine if a specific change is a physical change or not. Some changes, such as a change in color, also can occur when new substances are formed during the change. When deciding whether a change is a physical change or not, ask yourself whether you have the same substance you started with. If the substance is the same, then the changes it underwent were all physical changes.

Physical Changes

The process of turning wool into a sweater requires that the wool undergo physical changes. Changes in shape, volume, texture, and color occur as raw wool is turned into a colorful sweater.

1 Shearing

Preparing the wool produces physical changes. The wool is removed from the sheep and then cleaned before the wool fibers are separated.

2 Spinning

Further physical changes occur as a machine twists the wool fibers into a long, thin rope of yarn.

3 Dyeing

Dyeing produces color changes but does not change the basic substance of the wool.

4 The final product, a wool sweater, is still wool.

READING VISUALS How does the yarn in the sweater differ from the wool on the sheep?

Chemical properties describe how substances form new substances.

RESOURCE CENTER
CLASSZONE.COM

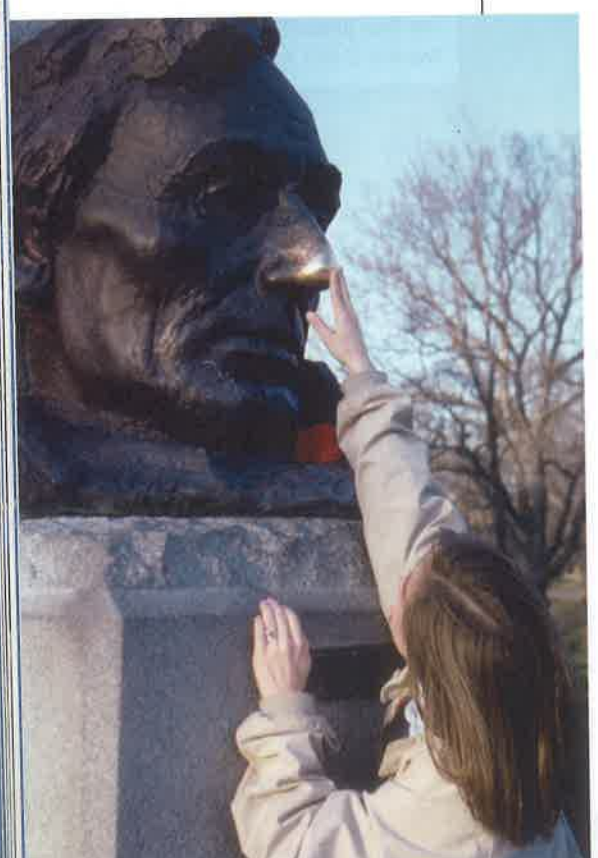
Learn about the chemical properties of matter.

If you wanted to keep a campfire burning, would you add a piece of wood or a piece of iron? You would add wood, of course, because you know that wood burns but iron does not. Is the ability to burn a physical property of the wood? The ability to burn seems to be quite different from physical properties such as color, density, and shape. More important, after the wood burns, all that is left is a pile of ashes and some new substances in the air. The wood has obviously changed into something else. The ability to burn, therefore, must describe another kind of property that substances have—not a physical property but a chemical property.

Chemical Properties and Changes

Chemical properties describe how substances can form new substances. Combustibility, for example, describes how well an object can burn. Wood burns well and turns into ashes and other substances. Can you think of a chemical property for the metal iron? Especially when left outdoors in wet weather, iron rusts. The ability to rust is a chemical property of iron. The metal silver does not rust, but eventually a darker substance called tarnish forms on its surface. You may have noticed a layer of tarnish on some silver spoons or jewelry.

INFER The bust of Abraham Lincoln is made of bronze. Why is the nose a different color from the rest of the head?



The chemical properties of copper cause it to become a blue-green color when it is exposed to air. A famous example of tarnished copper is the Statue of Liberty. The chemical properties of bronze are different. Some bronze objects tarnish to a dark brown color, like the bust of Abraham Lincoln in the photograph on the left.

Chemical properties can be identified by the changes they produce. The change of one substance into another substance is called a **chemical change.** A piece of wood burning, an iron fence rusting, and a silver spoon tarnishing are all examples of chemical changes. A chemical change affects the substances involved in the change. During a chemical change, combinations of atoms in the original substances are rearranged to make new substances. For example, when rust forms on iron, the iron atoms combine with oxygen atoms in the air to form a new substance that is made of both iron and oxygen.

A chemical change is also involved when an antacid tablet is dropped into a glass of water. As the tablet dissolves, bubbles of gas appear. The water and the substances in the tablet react to form new substances. One of these substances is carbon dioxide gas, which forms the bubbles that you see.

Not all chemical changes are as destructive as burning, rusting, or tarnishing. Chemical changes are also involved in cooking. When you boil an egg, for example, the substances in the raw egg change into new substances as energy is added to the egg. When you eat the egg, further chemical changes take place as your body digests the egg. The process forms new molecules that your body then can use to function.

CHECK YOUR READING Give three examples of chemical changes.

The only true indication of a chemical change is that a new substance has been formed. Sometimes, however, it is difficult to tell whether new substances have been formed or not. In many cases you have to judge which type of change has occurred only on the basis of your observations of the change and your previous experience. However, some common signs can suggest that a chemical change has occurred. You can use these signs to guide you as you try to classify a change that you are observing.

INVESTIGATE Chemical Changes

What are some signs of a chemical change?

PROCEDURE

1. Measure 80 mL of water and pour it into one of the cups.
2. Add 3 full droppers of iodine solution. Record your observations.
3. Add 1 spoonful of cornstarch to the iodine solution and stir. Record your observations.
4. Measure 50 mL of water and pour it into the second cup.
5. Using a clean eyedropper, add 4 full droppers of the iodine/cornstarch solution to the second cup.
6. Drop a vitamin C tablet into the second cup and stir the liquid with a clean spoon until the tablet is dissolved. Record your observations.

WHAT DO YOU THINK?

- What changes did you observe in the first cup? in the second cup?
- Do you think that chemical changes occurred? Why or why not?
- What are some characteristics of chemical changes?

CHALLENGE Describe some chemical changes that you have seen take place in your home or school.

SKILL FOCUS
Measuring

MATERIALS
- graduated cylinder
- water
- 2 clear plastic cups
- 2 eyedroppers
- iodine solution
- cornstarch
- spoon
- vitamin C tablet

TIME
15 minutes

Signs of a Chemical Change

You may not be able to see that any new substances have formed during a change. Below are some signs that a chemical change may have occurred. If you observe two or more of these signs during a change, you most likely are observing a chemical change.

Carbon dioxide bubbles form as substances in the tablet react with water.

Production of an Odor Some chemical changes produce new smells. The chemical change that occurs when an egg is rotting produces the smell of sulfur. If you go outdoors after a thunderstorm, you may detect an unusual odor in the air. The odor is an indication that lightning has caused a chemical change in the air.

Change in Temperature Chemical changes often are accompanied by a change in temperature. You may have noticed that the temperature is higher near logs burning in a campfire.

Change in Color A change in color is often an indication of a chemical change. For example, fruit may change color when it ripens.

Formation of Bubbles When an antacid tablet makes contact with water, it begins to bubble. The formation of gas bubbles is another indicator that a chemical change may have occurred.

Formation of a Solid When two liquids are combined, a solid called a precipitate can form. The shells of animals such as clams and mussels are precipitates. They are the result of a chemical change involving substances in seawater combining with substances from the creatures.

CHECK YOUR READING Give three signs of chemical changes. Describe one that you have seen recently.

2.1 Review

KEY CONCEPTS

1. What effect does observing a substance's physical properties have on the substance?
2. Describe how a physical property such as mass or texture can change without causing a change in the substance.
3. Explain why burning is a chemical change in wood.

CRITICAL THINKING

4. **Synthesize** Why does the density of a substance remain the same for different amounts of the substance?
5. **Calculate** What is the density of a block of wood with a mass of 120 g and a volume of 200 cm^3?

CHALLENGE

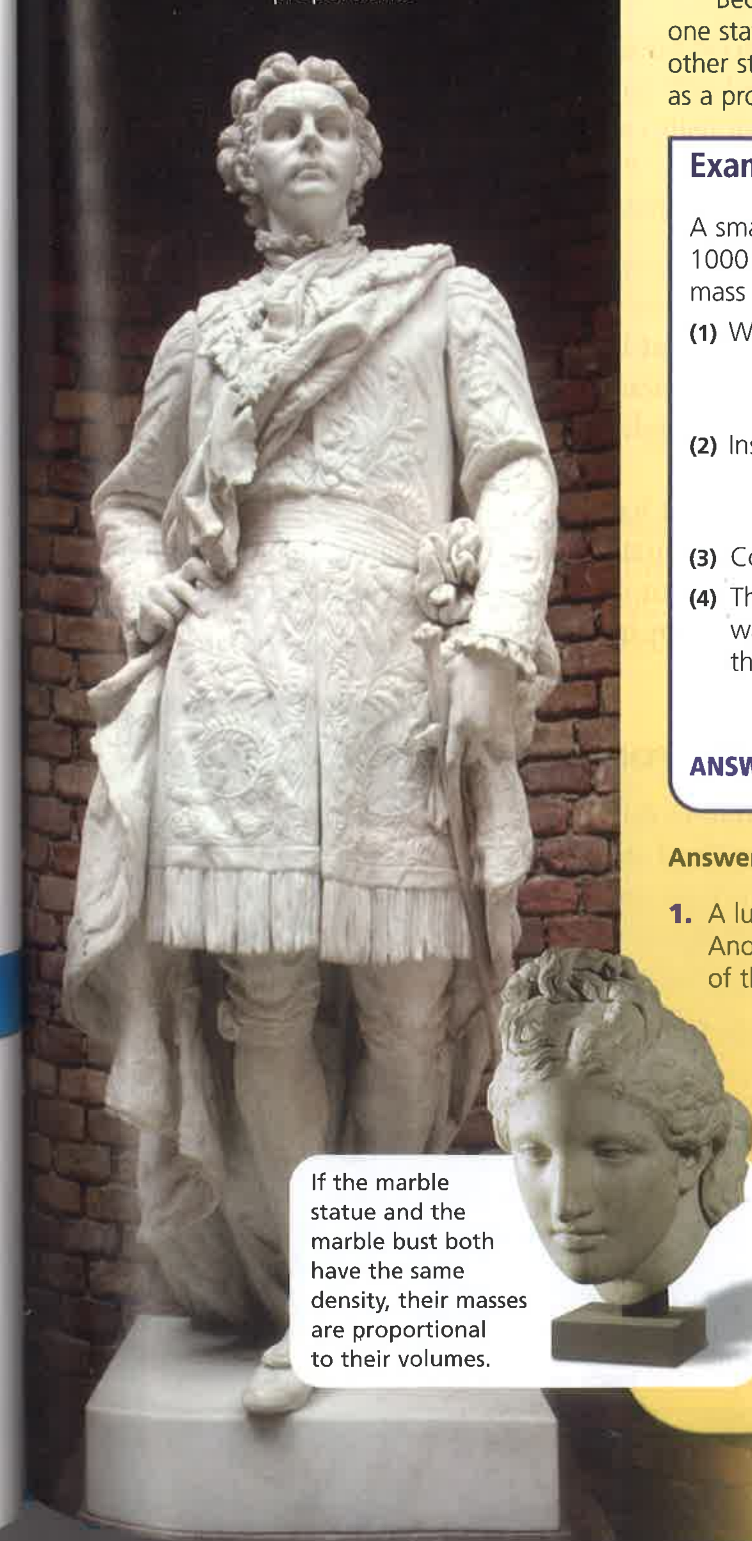
6. **Infer** Iron can rust when it is exposed to oxygen. What method could be used to prevent iron from rusting?

MATH in SCIENCE

SKILL: SOLVING PROPORTIONS

Density of Materials

MATH TUTORIAL
CLASSZONE.COM
Click on Math Tutorial for more help with solving proportions.



If the marble statue and the marble bust both have the same density, their masses are proportional to their volumes.

Two statues are made of the same type of marble. One is larger than the other. However, they both have the same density because they are made of the same material. Recall the formula for density.

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

Because the density is the same, you know that the mass of one statue divided by its volume is the same as the mass of the other statue divided by its volume. You can set this up and solve it as a proportion.

Example

A small marble statue has a mass of 2.5 kg and a volume of 1000 cm^3. A large marble statue with the same density has a mass of 10 kg. What is the volume of the large statue?

(1) Write the information as an equation showing the proportion.

$$\frac{\text{mass of small statue}}{\text{volume of small statue}} = \frac{\text{mass of large statue}}{\text{volume of large statue}}$$

(2) Insert the known values into your equation.

$$\frac{2.5\text{ kg}}{1000\text{ cm}^3} = \frac{10\text{ kg}}{\text{volume of large statue}}$$

(3) Compare the numerators: 10 kg is 4 times greater than 2.5 kg.

(4) The denominators of the fractions are related in the same way. Therefore, the volume of the large statue is 4 times the volume of the small one.

$$\text{volume of large statue} = 4 \cdot 1000\text{ cm}^3 = 4000\text{ cm}^3$$

ANSWER The volume of the large statue is 4000 cm^3.

Answer the following questions.

1. A lump of gold has a volume of 10 cm^3 and a mass of 193 g. Another lump of gold has a mass of 96.5 g. What is the volume of the second lump of gold?
2. A carpenter saws a wooden beam into two pieces. One piece has a mass of 600 g and a volume of 1000 cm^3. What is the mass of the second piece if its volume is 250 cm^3?
3. A 200 mL bottle is completely filled with cooking oil. The oil has a mass of 180 g. If 150 mL of the oil is poured into a pot, what is the mass of the poured oil?

CHALLENGE You have two spheres made of the same material. One has a diameter that is twice as large as the other. How do their masses compare?

KEY CONCEPT

2.2 Changes of state are physical changes.

BEFORE, you learned

- Substances have physical and chemical properties
- Physical changes do not change a substance into a new substance
- Chemical changes result in new substances

NOW, you will learn

- How liquids can become solids, and solids can become liquids
- How liquids can become gases, and gases can become liquids
- How energy is related to changes of state

VOCABULARY

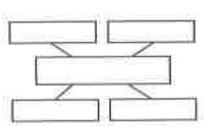
melting p. 51
melting point p. 51
freezing p. 52
freezing point p. 52
evaporation p. 53
sublimation p. 53
boiling p. 54
boiling point p. 54
condensation p. 55

THINK ABOUT

Where does dew come from?

On a cool morning, droplets of dew cover the grass. Where does this water come from? You might think it had rained recently. However, dew forms even if it has not rained. Air is made of a mixture of different gases, including water vapor. Some of the water vapor condenses—or becomes a liquid—on the cool grass and forms drops of liquid water.

MAIN IDEA WEB
Remember to place each blue heading in a box. Add details around it to form a web.



Matter can change from one state to another.

Matter is commonly found in three states: solid, liquid, and gas. A solid has a fixed volume and a fixed shape. A liquid also has a fixed volume but takes the shape of its container. A gas has neither a fixed volume nor a fixed shape. Matter always exists in one of these states, but it can change from one state to another.

When matter changes from one state to another, the substance itself does not change. Water, ice, and water vapor are all the same basic substance. As water turns into ice or water vapor, the water molecules themselves do not change. What changes are the arrangement of the molecules and the amount of space between them. Changes in state are physical changes because changes in state do not change the basic substance.

CHECK YOUR READING Why is a change in state a physical change rather than a chemical change?

Solids can become liquids, and liquids can become solids.

If you leave an ice cube on a kitchen counter, it changes to the liquid form of water. Water changes to the solid form of water, ice, when it is placed in a freezer. In a similar way, if a bar of iron is heated to a high enough temperature, it will become liquid iron. As the liquid iron cools, it becomes solid iron again.

Melting

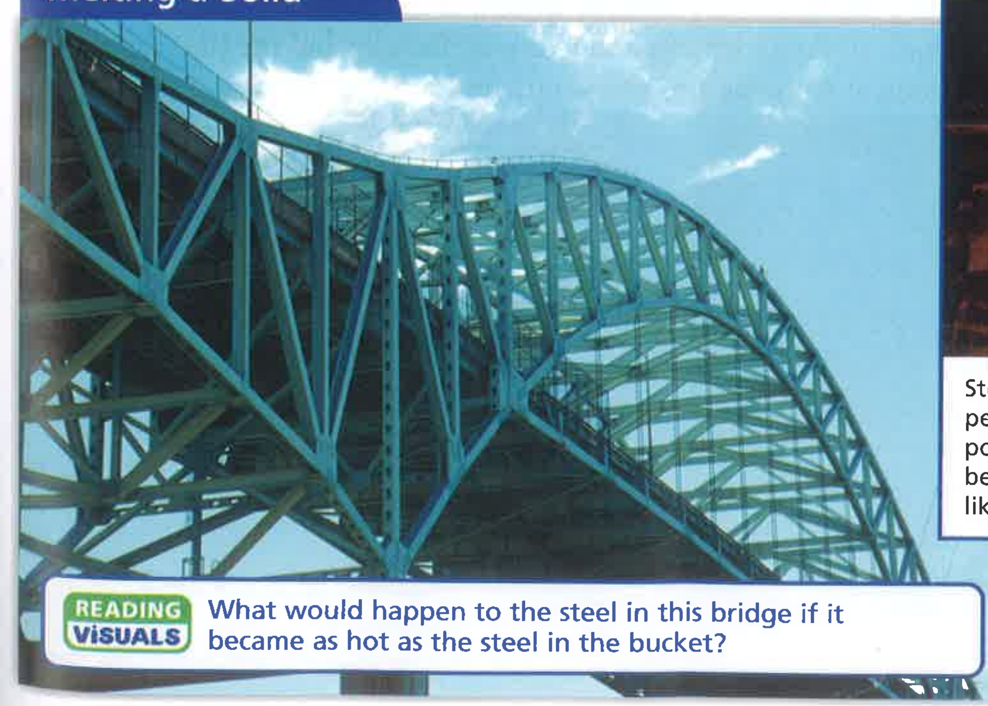
Melting is the process by which a solid becomes a liquid. Different solids melt at different temperatures. The lowest temperature at which a substance begins to melt is called its **melting point.** Although the melting point of ice is 0°C (32°F), iron must be heated to a much higher temperature before it will melt.

VOCABULARY
Add magnet word diagrams for *melting* and *melting point* to your notebook.

Remember that particles are always in motion, even in a solid. Because the particles in a solid are bound together, they do not move from place to place—but they do vibrate. As a solid heats up, its particles gain energy and vibrate faster. If the vibrations are fast enough, the particles break loose and slide past one another. In other words, the solid melts and becomes a liquid.

Some substances have a well-defined melting point. If you are melting ice, for example, you can predict that when the temperature reaches 0°C, the ice will start to melt. Substances with an orderly structure start melting when they reach a specific temperature.

Melting a Solid



Steel melts at very high temperatures. Liquid steel can be poured into molds to form the beams that are used in bridges like the one shown on the left.

READING VISUALS What would happen to the steel in this bridge if it became as hot as the steel in the bucket?

Other substances, such as plastic and chocolate, do not have a well-defined melting point. Chocolate becomes soft when the temperature is high enough, but it still maintains its shape. Eventually, the chocolate becomes a liquid, but there is no specific temperature at which you can say the change happened. Instead, the melting happens gradually over a range of temperatures.

CHECK YOUR READING Describe the movement of molecules in a substance that is at its melting point.

Icicles grow as water drips down them, freezes, and sticks to the ice that is already there. On a warm day, the frozen icicles melt again.

Freezing

Freezing is the process by which a liquid becomes a solid. Although you may think of cold temperatures when you hear the word *freezing,* many substances are solid, or frozen, at room temperature and above. Think about a soda can and a candle. The can and the candle are frozen at temperatures you would find in a classroom.

READING TIP
On the Celsius temperature scale, under normal conditions, water freezes at 0°C and boils at 100°C. On the Fahrenheit scale, water freezes at 32°F and boils at 212°F.

As the temperature of a liquid is lowered, its particles lose energy. As a result, the particles move more slowly. Eventually, the particles move slowly enough that the attractions among them cause the liquid to become a solid. The temperature at which a specific liquid becomes a solid is called the **freezing point** of the substance.

The freezing point of a substance is the same as that substance's melting point. At this particular temperature, the substance can exist as either a solid or a liquid. At temperatures below the freezing/melting point, the substance is a solid. At temperatures above the freezing/melting point, the substance is a liquid.

CHECK YOUR READING What is the relationship between a substance's melting point and freezing point?

Liquids can become gases, and gases can become liquids.

Suppose you spill water on a picnic table on a warm day. You might notice that the water eventually disappears from the table. What has happened to the water molecules? The liquid water has become water vapor, a gas. The water vapor mixes with the surrounding air. At the same picnic, you might also notice that a cold can of soda has beads of water forming on it. The water vapor in the air has become the liquid water found on the soda can.

Evaporation

Evaporation is a process by which a liquid becomes a gas. It usually occurs at the surface of a liquid. Although all particles in a liquid move, they do not all move at the same speed. Some particles move faster than others. The fastest moving particles at the surface of the liquid can break away from the liquid and escape to become gas particles.

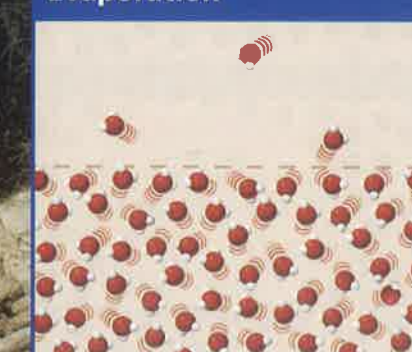
READING TIP
The root of the word *evaporation* is *vapor,* a Latin word meaning "steam."

As the temperature increases, the energy in the liquid increases. More particles can escape from the surface of the liquid. As a result, the liquid evaporates more quickly. This is why spilled water will evaporate faster in hot weather than in cold weather.

CHECK YOUR READING Describe the movement of particles in a liquid as it evaporates.

It is interesting to note that under certain conditions, solids can lose particles through a process similar to evaporation. When a solid changes directly to a gas, the process is called **sublimation.** You may have seen dry ice being used in a cooler to keep foods cold. Dry ice is frozen carbon dioxide that sublimates in normal atmospheric conditions.

Evaporation



During evaporation, fast-moving particles escape from the surface of a liquid and become gas particles.

RESOURCE CENTER
CLASSZONE.COM
Explore melting points and boiling points.

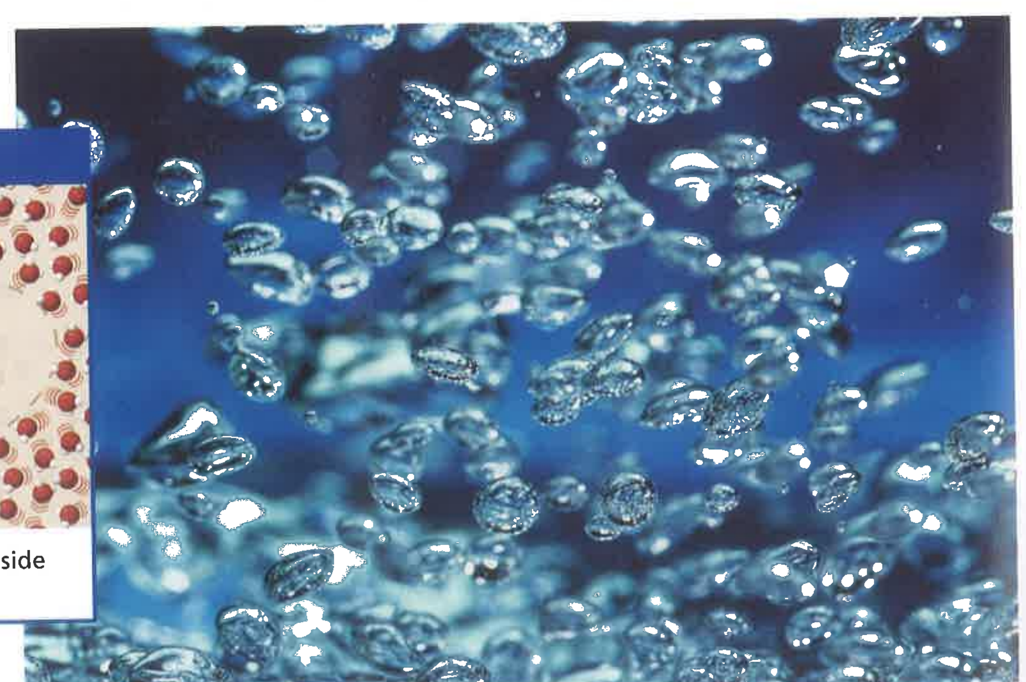
Boiling

Boiling is another process by which a liquid becomes a gas. Unlike evaporation, boiling produces bubbles. If you heat a pot of water on the stove, you will notice that after a while tiny bubbles begin to form. These bubbles contain dissolved air that is escaping from the liquid. As you continue to heat the water, large bubbles suddenly form and rise to the surface. These bubbles contain energetic water molecules that have escaped from the liquid water to form a gas. This process is boiling.

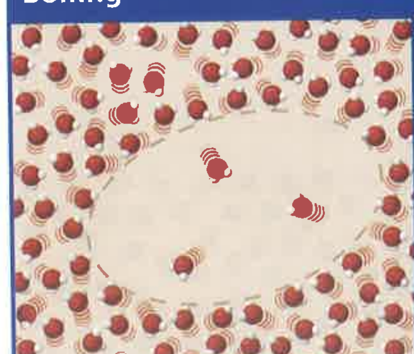
Boiling can occur only when the liquid reaches a certain temperature, called the **boiling point** of the liquid. Liquids evaporate over a wide range of temperatures. Boiling, however, occurs at a specific temperature for each liquid. Water, for example, has a boiling point of 100°C (212°F) at normal atmospheric pressure.

In the mountains, water boils at a temperature lower than 100°C. For example, in Leadville, Colorado, which has an elevation of 3094 m (10,152 ft) above sea level, water boils at 89°C (192°F). This happens because at high elevations the air pressure is much lower than at sea level. Because less pressure is pushing down on the surface of the water, bubbles can form inside the liquid at a lower temperature. Less energetic water molecules are needed to expand the bubbles under these conditions. The lower boiling point of water means that foods cooked in water, such as pasta, require a longer time to prepare.

Different substances boil at different temperatures. Helium, which is a gas at room temperature, boils at –270°C (–454°F). Aluminum, on the other hand, boils at 2519°C (4566°F). This fact explains why some substances usually are found as gases but others are not.



Boiling



Bubbles of vapor form inside the boiling water.

Tiny droplets of water form on a window as water vapor from the air condenses into liquid water.

Condensation

The process by which a gas changes its state to become a liquid is called **condensation.** You probably have seen an example of condensation when you enjoyed a cold drink on a warm day. The beads of water that formed on the glass or can were water vapor that condensed from the surrounding air.

The cold can or glass cooled the air surrounding it. When you cool a gas, it loses energy. As the particles move more slowly, the attractions among them cause droplets of liquid to form. Condensed water often forms when warm air containing water vapor comes into contact with a cold surface, such as a glass of ice or ground that has cooled during the night.

As with evaporation, condensation can occur over a wide range of temperatures. Like the particles in liquids, the individual particles in a gas are moving at many different speeds. Slowly moving particles near the cool surface condense as they lose energy. The faster moving particles also slow down but continue to move too fast to stick to the other particles in the liquid that is forming. However, if you cool a gas to a temperature below its boiling point, almost all of the gas will condense.

READING TIP
The root of the word *condensation* is *condense,* which comes from a Latin word meaning "to thicken."

2.2 Review

KEY CONCEPTS

1. Describe three ways in which matter can change from one state to another.
2. Compare and contrast the processes of evaporation and condensation.
3. How does adding energy to matter by heating it affect the energy of its particles?

CRITICAL THINKING

4. **Synthesize** Explain how water can exist as both a solid and a liquid at 0°C.
5. **Apply** Explain how a pat of butter at room temperature can be considered to be frozen.

CHALLENGE

6. **Infer** You know that water vapor condenses from air when the air temperature is lowered. Should it be possible to condense oxygen from air? What would have to happen?